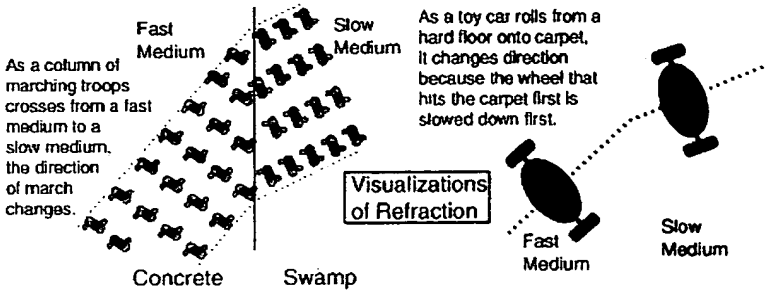
EXHIBIT A

Refraction of Sound

Refraction is the bending of waves when they enter a medium where their speed is different. Refraction is not so important a phenomena with sound as it is with light where it is responsible for image formation by lenses, the eye, cameras, etc. But bending of sound waves does occur and is an interesting phenomena in sound



Visualizations of Refraction

These visualizations may help in understanding the nature of refraction. A column of troops approaching a medium where their speed is slower as shown will turn toward the right because the right side of the column hits the slow medium first and is therefore slowed down. The marchers on the left, perhaps oblivious to the plight of their companions, continue to march ahead full speed until they hit the slow medium.

Not only does the direction of march change, the separation of the marchers is decreased. When applied to waves, this implies that the direction of propagation of the wave is deflected toward the right and that the wavelength of the wave is decreased. From the basic wave relationship, $v=f\lambda$, it is clear that a slower speed must shorten the wavelength since the frequency of the wave is determined by its source and does not change.

Another visualization of refraction can come from the steering of various types of tractors, construction equipment, tanks and other tracked vehicle. If you apply the right brake, the vehicle turns right because you have slowed down one side of the vehicle without slowing down the other.

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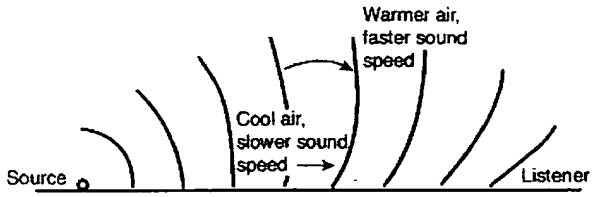
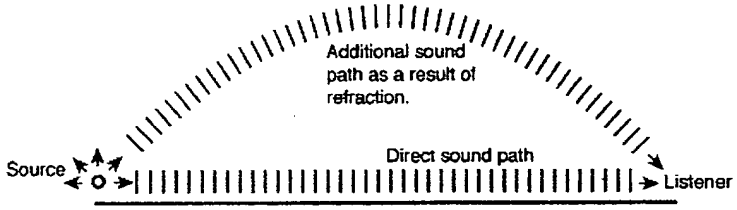
Refraction of Sound

If the air above the earth is warmer than that at the surface, sound will be bent back downward toward the surface by refraction.



Sound propagates in all directions from a point source. Normally, only that which is initially directed toward the listener can be heard, but refraction can bend sound downward. Normally, only the direct sound is received. But refraction can add some additional sound, effectively amplifying the sound. Natural amplifiers can occur over cool lakes.



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Refraction of Sound

Early morning fishermen may be the persons most familiar with the

refraction of sound. Consider that you have gone out to a lake before dawn. Just as the sun rises over a cool lake, you may hear someone speak to you, saying "Good morning!". You look around and can't see anyone. You are just about at the point of questioning your sanity anyway, being out at this time of the morning, so you decide to ignore it. But the voice comes again, "Good morning". Finally you locate the other nut who has gotten up at this hour, far across the lake -- much further than you could normally hear a voice. That fisherman is aware of the early morning lake's effect on sound transmission. The cool water keeps the air near the water cool, but the early sun has begun to heat the air higher up, creating a "thermal inversion". The fact that the speed of sound is faster in warmer air bends some sound back downward toward you - sound that would not reach your ear under normal circumstances. This natural amplification over cool bodies of water is one of the few natural examples of sound refraction.

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